



Octel Deutschland GmbH

# The Use of Ferrocene-Based Fuel Borne Catalysts

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## Filter Regeneration with satacen/Octimax



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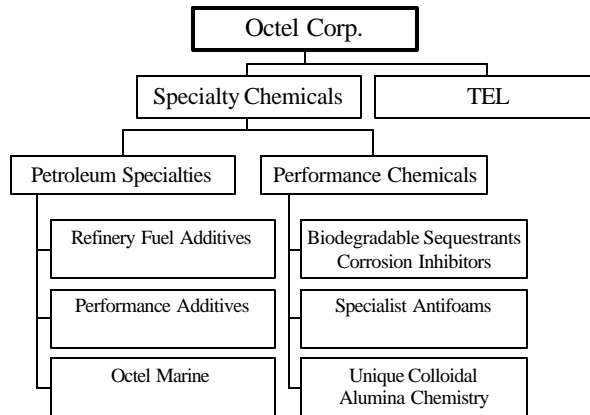
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# Octel Corp. Business Structure



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## The Company Octel



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- ◆ **US-based company (NYSE registered)**
- ◆ **A leading manufacturer of fuel additives with world-wide activities for:**
  - ⇒ Gasoline
  - ⇒ Light Heating Oil (LHO)
  - ⇒ Heavy Fuel Oil (HFO)
  - ⇒ Jet Fuel
  - ⇒ Diesel fuel, incl. additives for Particulate Filter Regeneration
- ◆ **Very high level of expertise in fuel technology**



## Activities

### Development, Production and Marketing of Special Petroleum Products



#### Additives for petroleum products

Diesel Detergent Packages  
Gasoline Detergents Packages  
Marker for Light Heating Oil (LHO)  
Anti-Static agents  
Combustion Improvers  
Stabilisers  
Lead Replacement Additives  
Fragrances

#### Special Chemical Compounds

Ferrocene Derivatives  
Metallocenes

#### Contract Synthesis and Trading

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## Diesel Particulate Filters



### Regeneration using Additives

#### Advantages

- Reliability of the system
- lower the ignition temperature of the soot down to approx. 350°C
- shorter burn out time of the soot at low temperatures

⇒ result in fuel consumption penalty estimated 5-10%

# Diesel Particulate Filters



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## Regeneration using Additives

### Further Advantages

- reduce particulate mass
- reduce total number of particulates
- higher trap efficiency up to 99.9% for fine particulates
- reduction of PAH's
- no increase in NO<sub>2</sub> emissions
- reduced thermal stress in filters
- no special requirement to the fuel used (low sulphur)

# The Additive



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## General Requirements

- highly effective
  - low concentration
  - low ash burden
  - compact additive storage
- non-toxic
  - additive itself
  - combustion products
- no influence on Diesel fuel specs, e. g. EN
  - cetane number
  - fuel stability (oxidation)
  - lubricity
  - emulsion forming tendency

# The Additive



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## Further Requirements

- no influence on engine out emissions
- compatible with any filter material
- acceptance from legal bodies
- acceptance from OEM

# The Octel Additives



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## satacen/Octimax - Overview

- ◆ Octel have been working on DPF regeneration additives for over 15 years
- ◆ satacen is the brand name for Germany, Austria and Switzerland
- ◆ Octel Octimax is the brand name for Rest of World
- ◆ satacen/Octimax packages are based on the fuel soluble iron organic compound ferrocene
- ◆ Octel is currently the largest additive supplier to the retrofit DPF market
- ◆ satacen / Octimax additives are fully fuel soluble and stable
- ◆ satacen / Octimax are supported by extensive no harm testing in a wide range of diesel engines.

# The Active Compound Ferrocene



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## Properties

- ◆ iron organic compound
- ◆ highly soluble in hydrocarbon solvents
- ◆ catalytic effects during combustion
- ◆ resistant against water, air, light and heat
- ◆ easy handling



The compound

# The Active Compound Ferrocene



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## Toxicological Properties

- ◆ Not an irritant/does not sensitize the skin
- ◆ low toxicity for water organisms
- ◆ highly biodegradable
- ◆ low acute and sub-acute mammal toxicity
- ◆ no indication of carcinogenic effects

# The Active Compound Ferrocene



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## Toxicological Properties of Ferrocene Combustion Products

### Gasoline

- ◆ iron-oxides are non-critical
- ◆ no gaseous iron compounds
- ◆ no chronic toxicity detectable in the catalytic converter exhaust gases
- ◆ no carcinogenicity detectable in the catalytic converter exhaust gases

### Diesel

- ◆ no differences between Diesel exhaust gases with and without Ferrocene in the Ames-Test

US National Toxicology Program,  
Fraunhofer (Fh-ITA, Fh-IUCT),  
Svensk Bilprovning

## Research-Investigation-Tests



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<b>Diesel</b>	<b>VERT-Testing (Biel Polytechnic, Switzerland)</b> <ul style="list-style-type: none"><li>- Efficiency of filter / Precipitation rate</li><li>- Influence of Additive on engine out emission</li></ul>
	<b>EMPA (Swiss Federal Laboratories for Materials Testing and Research)</b> <ul style="list-style-type: none"><li>- Dioxins</li><li>- Nitro PAH</li></ul>
<b>Gasoline</b>	<b>Fraunhofer Institut für Toxikologie und Aerosolforschung, Germany</b> <ul style="list-style-type: none"><li>- Toxicology of the additive's combustion products</li></ul>
	<b>Svensk Bilprovning, Sweden</b> <ul style="list-style-type: none"><li>- Comparison of gasoline with and without additive</li></ul>
	<b>US National Toxicology Program</b> <ul style="list-style-type: none"><li>- Iron oxides in general</li></ul>
	<b>Inveresk Institute, Scotland</b> <ul style="list-style-type: none"><li>- Handling of the compound</li></ul>

**Results**      **No negative impacts monitored**

## Octel Additive Approvals



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### European Legal Bodies that accept or approve Octel's DPF additives

- ✓ German UBA (Federal Environmental Agency)
- ✓ Swiss BUWAL (Federal Office of Environment)
  - ✓ Approval for various filter-additive combinations
- ✓ French Ministry of Environment.
- ✓ UK Department of health ( DoH)
- ✓ Swedish EPA - MTC centre
- ✓ The above approvals are required for sale of additive to the OEM's in Europe
- ✓ Liebherr Machines Bulle SA (Switzerland) - Original fit
- ✓ satacen/Octimax is scheduled for supply to original fit with a number of German and other European OEM's by 2005

## Field Experience



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### Passive Regeneration System (Only Additive)

Octel's additives are currently being successfully used in the following markets/customers:

- ◆ More than 1,000 construction vehicles/building machinery in Germany, Austria and Switzerland since 5 years
- ◆ several hundred city buses, garbage trucks, forklifters and cleaning machinery since several years in France
- ◆ bus fleets and garbage trucks in Denmark
- ◆ large scale field trial ongoing in Germany (Heavy Duty Trucks)
- ◆ Octel Exhaust systems - a large scale retrofit programme for the UK



## Conclusion



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### Additives as Regeneration Aid

- ◆ Reliability of the system
- ◆ Economical and cost-effective way of filter regeneration
- ◆ No influence on emissions
- ◆ No secondary emissions
- ◆ Reduction of particulate mass and number
- ◆ Accepted and approved by legal bodies and OEM's in Western Europe

## Ferrocene Working Mechanism



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### Burning Crude Oil



Without Ferrocene



With Ferrocene

Source: Sintef Institute - Trondheim, Norway